# Use of
# Integrated Vehicle Health Management in the Field of Commercial Aviation

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**Honeywell**
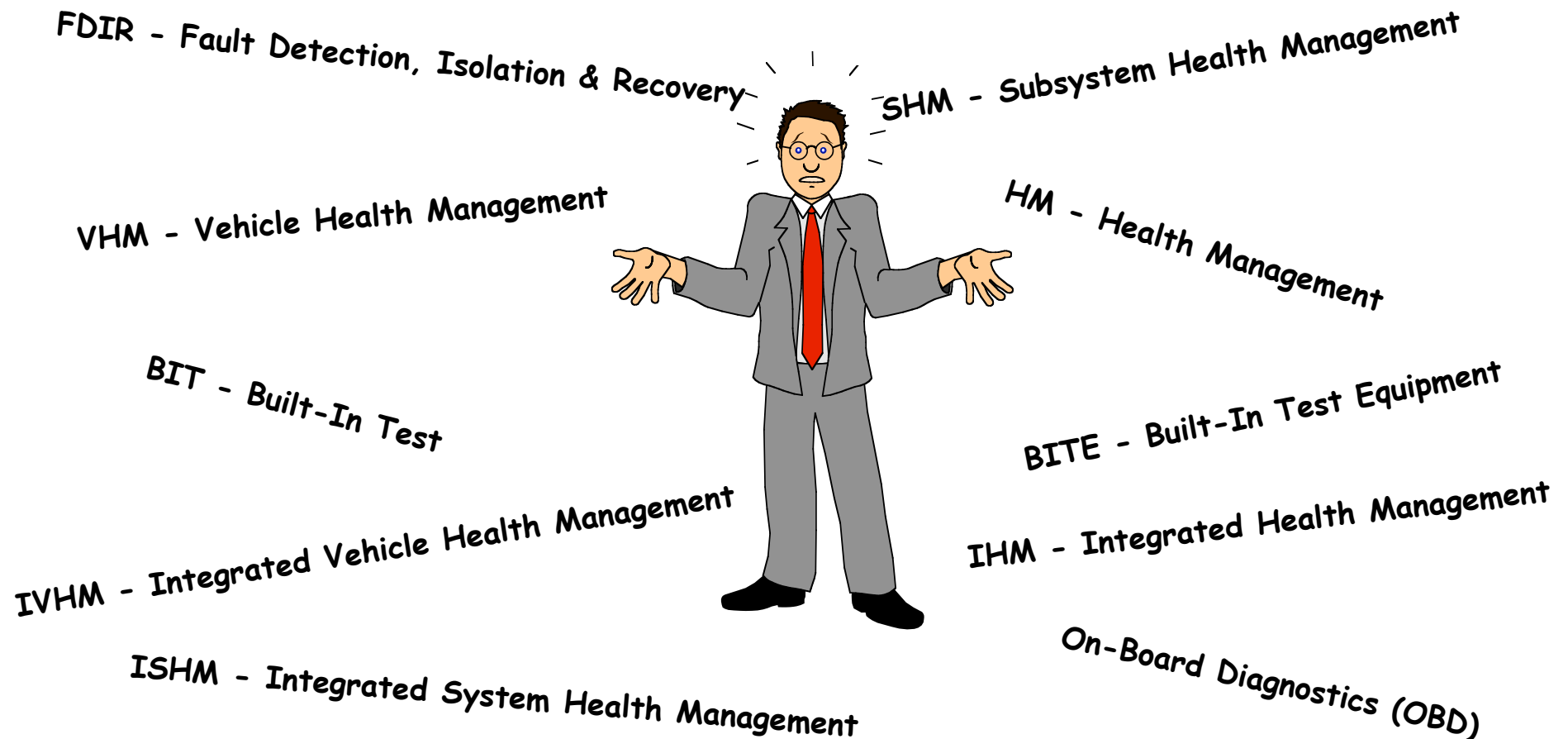
# Agenda

◆ **Health Management Defined**

◆ **Layered Approach to IVHM**

◆ **Evolution of Commercial Aviation IVHM**

  – **History**

  – **Industry Standards**

  – **Generations**

◆ **Next Generation Systems**

  – **Honeywell Primus Epic® Aircraft Diagnostic and Maintenance System**

  – **Boeing 787 Crew Information System / Maintenance System**

  – **Intelligent Vehicles, Sense & Respond**

◆ **Future Trends**

# Health Management Defined?

FDIR - Fault Detection, Isolation & Recovery

SHM - Subsystem Health Management

VHM - Vehicle Health Management

HM - Health Management

BIT - Built-In Test

BITE - Built-In Test Equipment

IVHM - Integrated Vehicle Health Management

IHM - Integrated Health Management

ISHM - Integrated System Health Management

On-Board Diagnostics (OBD)
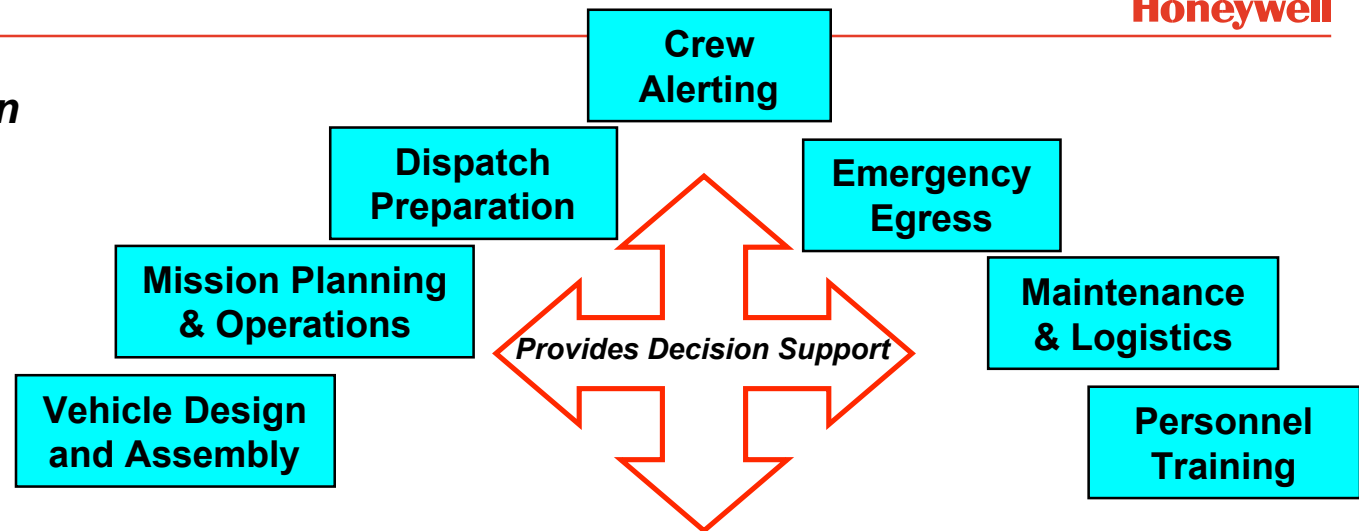
*Health Management Provides Users with an Integrated View of the Health State of the Overall "System"*

# Layered Approach to IVHM

**IVHM Provides Decision Support Capabilities Across the Enterprise**

Crew Alerting

Dispatch Preparation

Emergency Egress

Mission Planning & Operations

Maintenance & Logistics

*Provides Decision Support*

Vehicle Design and Assembly

Personnel Training

**IVHM Leverages Knowledge Across Subsystems**

IVHM

SHM

SHM

N500GA

**Effective Subsystem Health Management Serves as the Foundation of Effective IVHM**

SHM

SHM

SHM
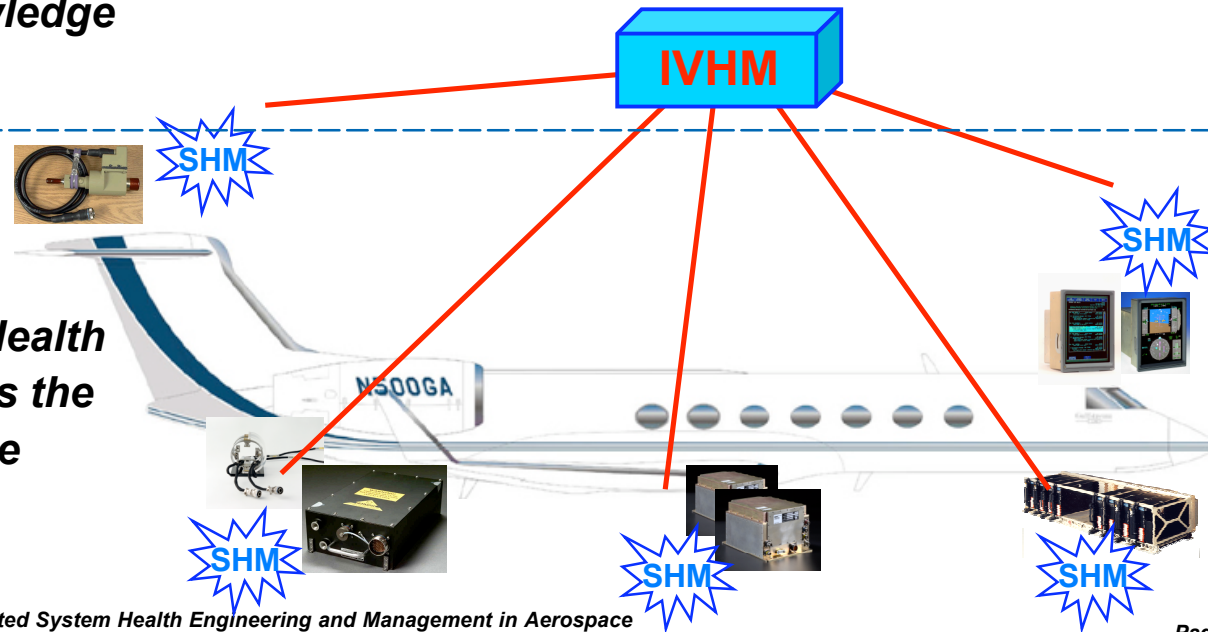
# Evolution of Commercial Aviation IVHM

**Honeywell**

- ◆ **Analog Systems (1950s, 60s, 70s)**
  - – **Cockpit visual indications (e.g., warning lights, red lines on gauges, etc.)**
  - – **"Push-to-Test" or "Go/No-Go Test"**
    - » **nothing more than a simple pushbutton that supplied current to the internal circuitry. If circuit continuity was detected, a green light would illuminate signifying a successful test.**

*1st Gen*

*Emergence of Standards*

- ◆ **Digital Systems (using hardware & software)**
  - – **Early 1980s**
    - » **Stand-alone LRUs using dedicated front panels with push-buttons and simple display capability (e.g., lights, alpha-numeric readouts)**
  - – **Mid 1980s**
    - » **Centralized display panels shared by several LRUs**
  - – **Late 1980s / Early 90s**
    - » **Centralized computers consuming heath and status data from several LRUs, performing simple fault consolidation and root-cause analysis**
    - » **Later addition of trending and simple prognostics**

*2nd Gen*

*3rd Gen*
*4th Gen*

# Industry Standards for Aircraft

**Honeywell**

- ◆ **Aeronautical Radio, Inc. (ARINC) is a key standards provider for Commercial and Military Aircraft & Rotorcraft**

- ◆ **VHM topics are within the scope of the Avionics Maintenance Conference (AMC) an air transport industry activity sponsored by ARINC**
  - **AMC objectives are to promote reliability and reduced operating cost in air transport avionics by improving maintenance and support techniques through the exchange of technical information**

- ◆ **Well known and recognized standards include**
  - **ARINC Report 604-1: Guidance for Design and Use of Built-In Test Equipment (BITE); October 1988**
  - **ARINC Specification 624-1: Design Guidance for Onboard Maintenance System; August 1993**
  - **ARINC Report 644: Portable Maintenance Access Terminal (PMAT); May 1993**

- ◆ **References**
  - **www.arinc.com/amc**

# Industry Standards - ARINC 604-1

**Honeywell**

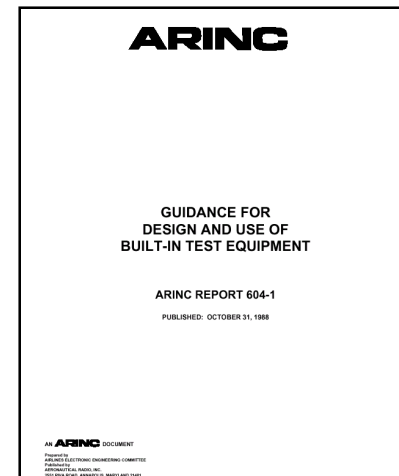*Guidance for Design and Use of Built-In Test Equipment (BITE)*

◆ **Purpose/Scope**
  - **The primary purpose of BITE is to assist maintenance personnel in the proper maintenance of avionics systems in a cost-effective manner. A description of a Centralized Fault Display System (CFDS) is included in this standard. The CFDS accumulates fault data, presents this data to a maintenance operator, and assists troubleshooting by performing diagnostic tests and performing verification testing after installation of a replacement unit.**

◆ **Major Sections**
  - **Goals for BITE**
  - **Maintenance Concept**
  - **BITE System Concepts**
  - **Centralized Fault Display System Concept**
    » **Display Formats, Interfaces, Protocols, etc.**

◆ **Version History**
  - **First release, ARINC 604 published 1985**
    » **Only supported character-based, block transmission protocol**
  - **Current release, ARINC 604-1 published 1988**
    » **Added bit-oriented, broadcast protocol**



**ARINC**

GUIDANCE FOR
DESIGN AND USE OF
BUILT-IN TEST EQUIPMENT

ARINC REPORT 604-1

PUBLISHED: OCTOBER 31, 1988

AN ARINC DOCUMENT

Prepared by
AIRLINES ELECTRONIC ENGINEERING COMMITTEE
Published by
AERONAUTICAL RADIO, INC.
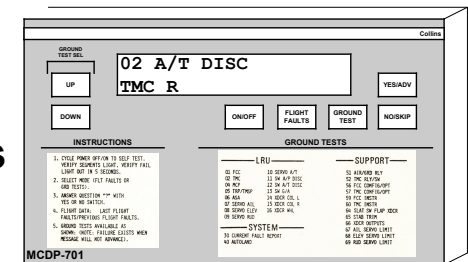2551 RIVA ROAD, ANNAPOLIS, MARYLAND 21401

# Industry Standards - ARINC 604-1

**Honeywell**

## Aircraft equipped with maintenance systems based on ARINC 604-1

◆ **Boeing 757, 767**

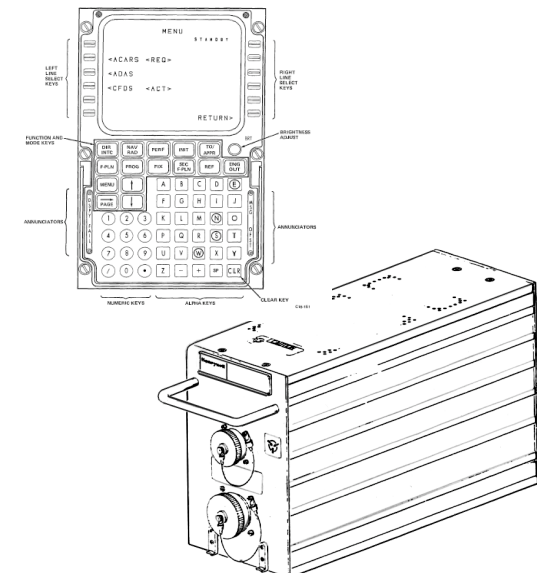   MCDP, Maintenance Control Display Panel - Rockwell Collins

◆ **MD-11, Boeing 717**

   CFDIU, Central Fault Display Interface Unit - Honeywell

◆ **Boeing 747-400**

   CMC, Central Maintenance Computer - Rockwell Collins
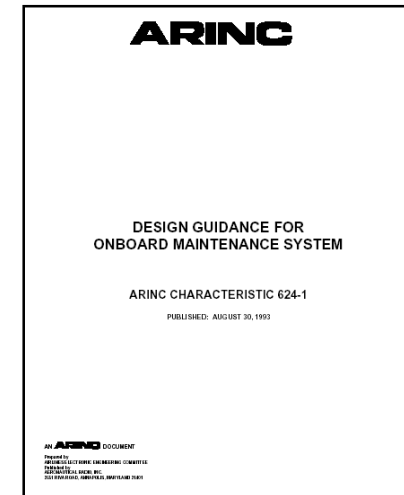
# Industry Standards - ARINC 624-1

Honeywell

*Design Guidance for Onboard Maintenance System*

- ◆ **Purpose/Scope**
  - **Enables continued improvement of avionics maintenance practices through On-Board Maintenance System (OMS) recording. This standard defines the OMS, which incorporates fault monitoring, fault detection, BITE and airplane condition monitoring.**
- ◆ **Major Sections**
  - **Maintenance Concept**
  - **OMS Description**
  - **CMC Design Considerations**
  - **OMS Member System BITE**
  - **OMS Communications Protocol**
  - **Onboard Maintenance Documentation**
  - **Airplane Condition Monitoring Function (ACMF)**
- ◆ **Version History**
  - **First release, ARINC 624 published 1991**
    - » **Only supported ARINC-429 databus**
  - **Current release, ARINC 624-1 published 1993**
    - » **Added support for additional databuses (e.g., ARINC-629)**
    - » **Incorporated lessons learned from previous ACMF implementations**

**ARINC**

**DESIGN GUIDANCE FOR ONBOARD MAINTENANCE SYSTEM**

**ARINC CHARACTERISTIC 624-1**

PUBLISHED: AUGUST 30, 1993

AN ARINC DOCUMENT

Prepared by
AIRLINES ELECTRONIC ENGINEERING COMMITTEE
Published by
AERONAUTICAL RADIO, INC.
2551 RIVA ROAD, ANNAPOLIS, MARYLAND 21401

# Industry Standards - ARINC 624-1

**Honeywell**

**Aircraft equipped with maintenance systems based on ARINC 624-1**

**Demo Systems LLC  PMAT/LD**

◆ **Boeing 777**

   **CMF, Central Maintenance Function - Honeywell**

   **Integrated into Aircraft Information Management System (AIMS)**

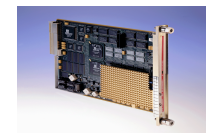◆ **Business Jets, Regional Jets, Rotorcraft**

   **ADMS, Aircraft Diagnostic and Maintenance System - Honeywell**

   **Integrated into Primus Epic® system**

   **Simplified variant of ARINC-604 & 624**

   *(bit-oriented protocol with centralized OMS)*

# VHM Evolution for Commercial Aircraft

**Next Gen?**

**Honeywell**

**Fourth Generation**

Modular avionics, using an integrated
CMC and limited datalink capability

» 777

**Third Generation**

Federated avionics using a CMC to
access all subsystems

» 747-400, MD-11

**Second Generation**

Digital Systems using front panel displays

» 757/767, 737NG, MD-90, A320

**First Generation**

Mechanical/Analog Systems using
Push-To-Test and fault indicator lights

» 727, DC-9 / MD-80, 737 Classic

# Honeywell Primus Epic
# Aircraft Diagnostic and Maintenance System
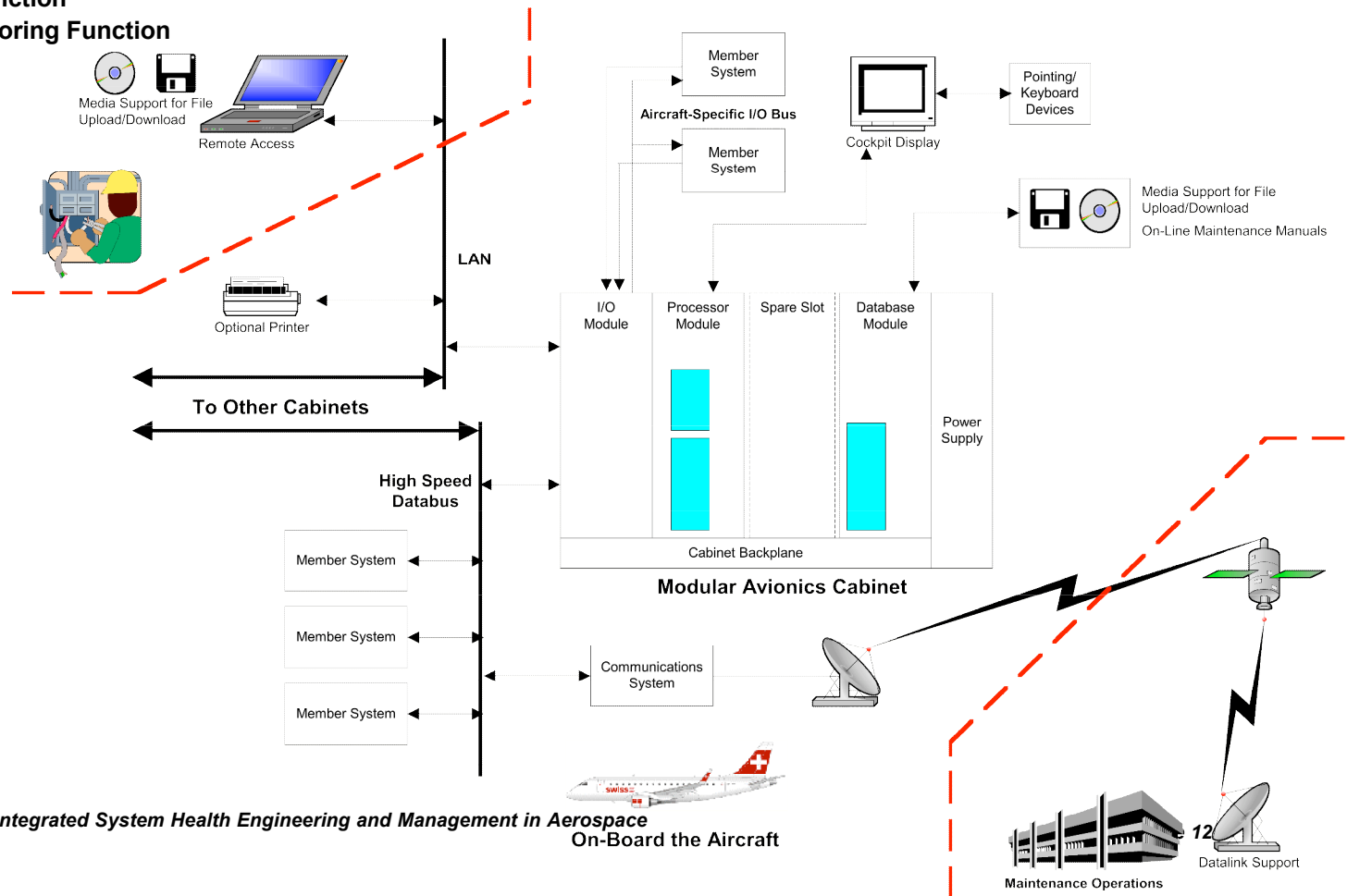
**Honeywell**

- **Aircraft**
  - Business Jets (Raytheon Hawker Horizon, Dassault F900EX/F2000EX/Falcon 7X, Gulfstream G450/G550, Cessna Sovereign)
  - Helicopters (Agusta AB-139)
  - Regional Jets (Embraer ERJ-170/190)
- **Aircraft Diagnostic and Maintenance System (ADMS)**
  - Central Maintenance Function
  - Aircraft Condition Monitoring Function
  - Member Systems' BIT

- **Features**
  - Includes coverage of Honeywell and Third-Party systems
  - Provides Single Point Access to all systems via "Point & Click" GUI
  - Performs Root Cause Diagnostics to Eliminate Cascaded Faults
  - Performs Correlation between Flight Deck Effects and System Faults
  - Configurable Via Database
  - Supports Printer, Data Link, & Floppy/CD-ROM

Media Support for File Upload/Download

Remote Access

LAN

Optional Printer

To Other Cabinets

High Speed Databus

Member System

Member System

Member System

Member System

Aircraft-Specific I/O Bus

Member System

Cockpit Display

Pointing/ Keyboard Devices

Media Support for File Upload/Download

On-Line Maintenance Manuals

| I/O Module | Processor Module | Spare Slot | Database Module | |
|---|---|---|---|---|
| | | | | Power Supply |

Cabinet Backplane

**Modular Avionics Cabinet**
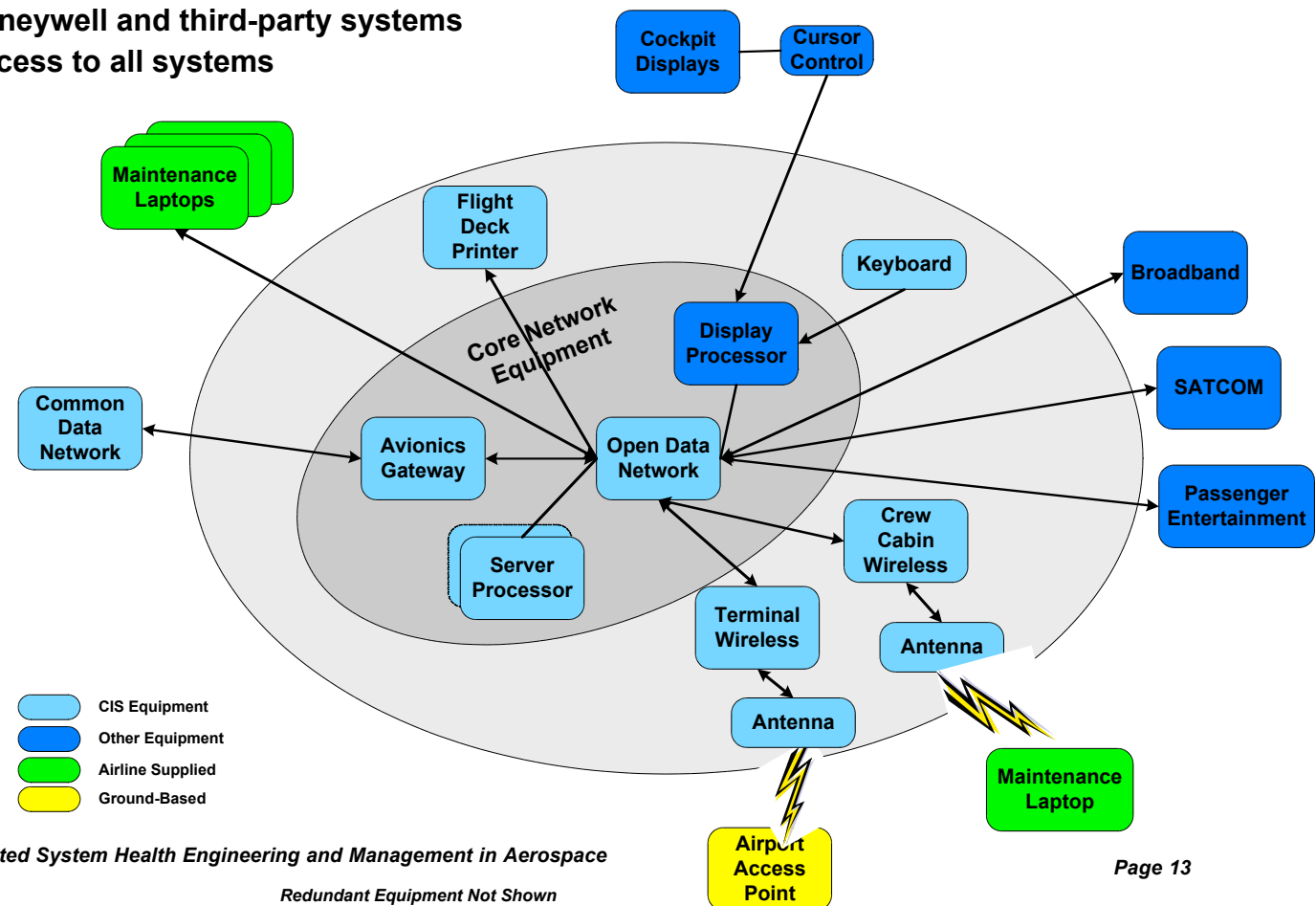
Communications System

**On-Board the Aircraft**

Datalink Support

Maintenance Operations

# Boeing 787
# Crew Information System / Maintenance System

◆ **Features**

- Leverages technologies from Boeing 777 CMC and Primus Epic ADMS
- Performs onboard, real-time data collection, fault processing and display
- Performs root cause diagnostics to eliminate cascaded faults
- Performs correlation between Flight Deck Effects and system faults
- E-enabled network to ground Maintenance Operations for extended diagnostic/prognostic analysis
- Includes coverage of Honeywell and third-party systems
- Provides single point access to all systems



**Legend:**
- CIS Equipment
- Other Equipment
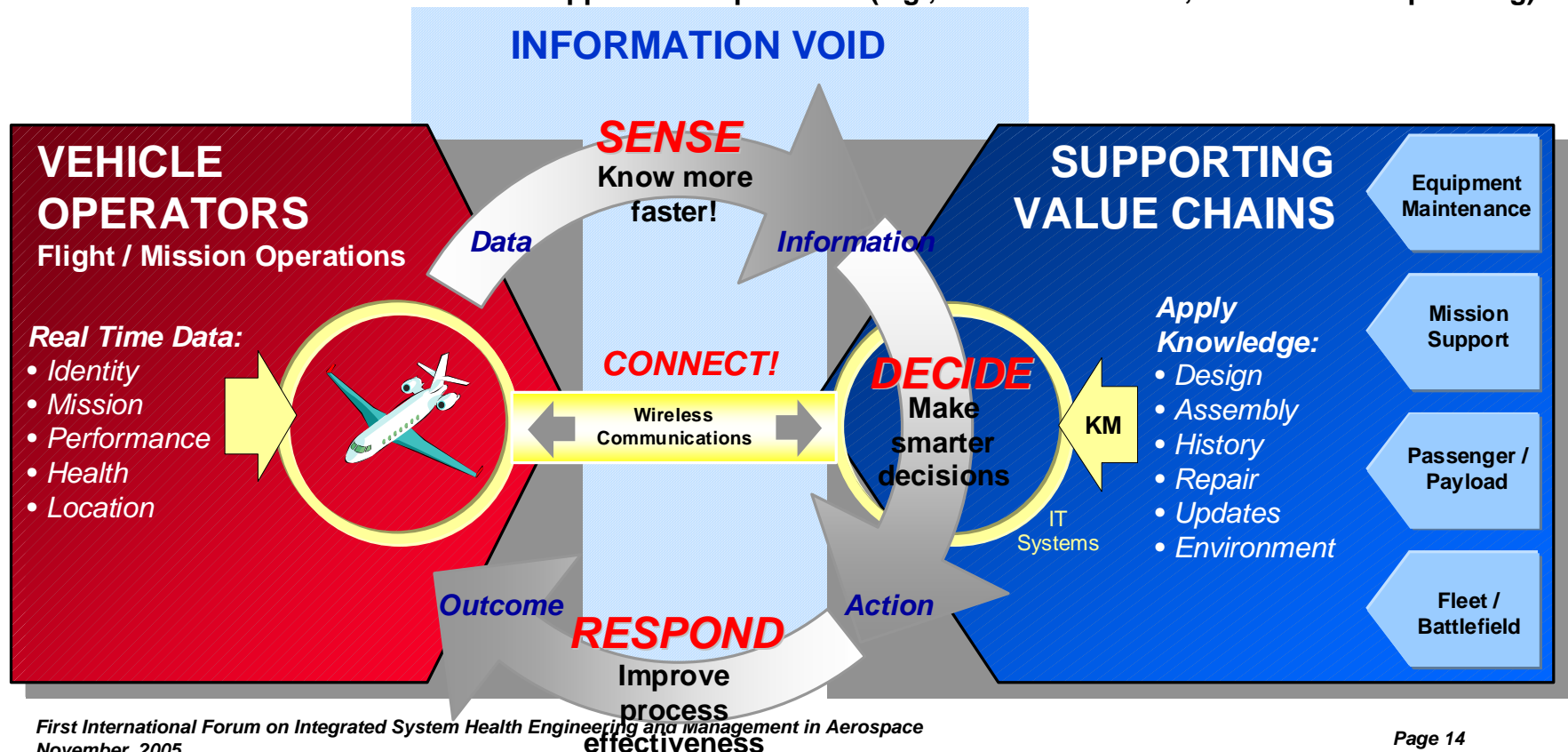- Airline Supplied
- Ground-Based

*First International Forum on Integrated System Health Engineering and Management in Aerospace*
*November, 2005*

*Redundant Equipment Not Shown*

# Intelligent Vehicles, Sense & Respond

**Honeywell**

- ◆ **Vehicles**
  - – **Aircraft (Honeywell, General Electric, Pratt & Whitney)**
  - – **Automotive (General Motors' OnStar®)**
- ◆ **Features**
  - – **Performs onboard, real-time data collection, fault processing**
  - – **Raw/Processed data transmitted to central data repository**
  - – **Data utilized by Engineering and Business processes (e.g., warranty, reliability, product improvement, logistics)**
  - – **Data made available to Customers to support their operations (e.g., fleet maintenance, fleet utilization planning)**

**INFORMATION VOID**

**SENSE**
Know more faster!

**VEHICLE OPERATORS**
Flight / Mission Operations

*Data*

*Information*

*Real Time Data:*
- *Identity*
- *Mission*
- *Performance*
- *Health*
- *Location*

**CONNECT!**

Wireless Communications

**DECIDE**
Make smarter decisions

**KM**

IT Systems

**SUPPORTING VALUE CHAINS**

*Apply Knowledge:*
- *Design*
- *Assembly*
- *History*
- *Repair*
- *Updates*
- *Environment*

Equipment Maintenance

Mission Support

Passenger / Payload

Fleet / Battlefield

*Outcome*

*Action*

**RESPOND**
Improve process effectiveness

# Future Trends

- ◆ **Advances in Commercial Aviation are focused on delivering value to the customer**
  - – **Life-cycle cost reduction**
  - – **Condition-based maintenance**
  - – **Fleet services**
- ◆ **IVHM systems are taking advantage of commercial technologies**
  - – **Wireless communications**
  - – **Web-enabled**
  - – **Aircraft becoming a "node" on the network**

*Commercial usage of IVHM is typically in support of maintenance*

- ◆ **NASA needs are of higher criticality - IVHM in support of**
  - – **Vehicle automation**
  - – **Vehicle reconfigurablity**
  - – **Mission planning and execution**

*More R&D is needed to adapt commercial IVHM technologies to the applications of human spaceflight - NASA must drive this R&D*